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Summary

Learning to read is an important competence to function in modern society. Nevertheless, roughly 15 % of Danish school children have poor reading abilities and it raises concerns (Christensen, 2018). How to enhance children's reading skills is therefore an important question. Movement in close connection with the learning content, *embodied learning*, has previously been seen to be an effective tool to improve academic performance within mathematics (e.g., Beck et al., 2016) and second language (e.g., Mavilidi, Okely, Chandler, Cliff, & Paas, 2015). It is still unknown whether embodied learning is an effective tool to improve literacy skills for children's first language. Therefore and to this aim, the present thesis investigated if meaningful movements in close connection to the learning content, have positive effects on children's pre-reading skills, word reading and spelling performance. We performed three school projects to investigate: I) whether embodied learning could enhance children's letter recognition in an acute setup (10 minutes), II) which forms of movements (hands/arms vs. whole-body) would have the highest effect on children's letter-sound knowledge and reading performance in a longitudinal study (8-weeks), and lastly III) whether movement would be extra beneficial for children with reading difficulties (4-weeks project). All three studies were performed with a strong focus on physical play.

Manuscript I investigated whether two movement interventions of 10 minutes could enhance children's letter recognition. Results show that fine motor movements (FME) had a higher effect on children's letter recognition compared to a non-motor movement group (CON) and gross-motor movement group (GME). This suggests that movement can be used to enhance children's literacy performance. **Manuscript II** investigated which motor modality would have the highest impact on children's letter-sound knowledge and reading performance. Children performing whole-body movements (WM) improved their letter-sound knowledge significantly compared to children using only their arms/hands (HM) as well as compared to a no-movement group (CON) after 8 weeks using embodied learning activities. In addition, HM had a higher long-term improvement in conditional letter-sounds compared to CON and WM. The results show that embodied learning is beneficial for children's pre-reading skills, and that both whole-body movements and hand-motor movements can enhance children's literacy performance. However and in contrast, no improvement was observed for reading performance. **Manuscript III** investigated whether the effect of embodied learning is determined by different levels in word reading performance at baseline in children. The results suggest that embodied learning improved spelling performance and letter-sound knowledge for both children with high reading ability at baseline and children with reading difficulties.

The present results of the thesis provide us with a basic understanding of the positive effects of embodied learning on children's pre-reading skills and spelling performance. Furthermore, it also provides evidence and understanding of which forms of movement are beneficial for improving pre-reading skills and spelling performance. However as evident from the present results, the motor modality used in connection with learning is probably not as important as the integration of the movement to the learning task (task integration). Hopefully, the thesis can contribute to increasing attention on the importance of learning activities with high task integration of movements in school.

Dansk resumé (Danish summary)

At lære at læse er en vigtig kompetence for at kunne begå sig i det moderne samfund. Ikke desto mindre har omkring 15% af danske skolebørn dårlige læseevner, og det vækker bekymring (Christensen, 2018). Hvordan man kan forbedre børns læsefærdigheder, er derfor et vigtigt område at undersøge. Bevægelse i tæt forbindelse med akademisk læring, bevægelsesberiget læring, har tidligere vist at være et effektivt værktøj til at forbedre akademisk præstation inden for matematik (Beck et al., 2016) og fremmedsprog (Mavilidi et al., 2015), men næsten ingen studier har undersøgt effekter på børns læsefærdigheder på modersmål. Formålet med denne afhandling er at undersøge meningsfulde bevægelser i tæt sammenhæng med akademisk lærings effekter på børns før-læseevner (bogstavgenkendelse, bogstav-lyd kendskab), ordlæsning og staveevner. Vi udførte tre skoleprojekter for at undersøge I) om bevægelsesberiget læring kunne forbedre børns bogstavgenkendelse i et akut studie (10 minutters intervention), II) hvilke former for bevægelse (hænder/arme vs. hele kroppen) ville have den største effekt på børns bogstav-lyd kendskab og læsepræstation i et længerevarende studie (8-uger) og endeligt III), om bevægelse ville være ekstra gavnligt for børn med læsevanskeligheder (4 ugers studie).

Manuskript I undersøgte, om to bevægelsesinterventioner i 10 minutter kunne øge børns bogstavgenkendelse. Resultaterne viste, at finmotoriske bevægelser (FME) havde en højere effekt på børns bogstavgenkendelse sammenlignet med en ikke-motorisk gruppe (CON) og en grovmotorisk bevægelsesgruppe (GME). Dette tyder på, at bevægelse kan bruges til at forbedre børns bogstavgenkendelsesevner, som er en vigtig færdighed, når man skal lære at læse. **Manuskript II** undersøgte hvilken motorisk modalitet der ville have den største indflydelse på børns bogstav-lyd kendskab og læsepræstation. Børn der udførte helkropsbevægelser (WM) forbedrede deres bogstav-lyd kendskab betydeligt sammenlignet med børn, der anvendte arme/hænder (HM) samt ingen bevægelse (CON), efter 8 uger med bevægelsesberiget læringsaktiviteter. Yderligere fandt vi, at HM havde en højere langvarig forbedring af betingede bogstavlyde sammenlignet med CON og WM. Resultaterne viser, at kropslig læring er gavnligt for børns bogstav-lyd kendskab, og at både helkropsbevægelser og håndmotoriske bevægelser kan forbedre børns kendskab til bogstavlyde, som er væsentlig for at kunne lære at læse. Dog fandt vi ingen effekter på læsning. **Manuskript III** undersøgte, om effekten af bevægelsesberiget læring bestemmes af forskellige niveauer i ordlæsningspræstation ved baseline hos børn. Resultaterne tyder på, at bevægelsesberiget læring forbedre staveevnen og bogstav-lyd kendskabet hos børn med gode læseevner og hos børn, der har udfordringer med at læse. Bevægelsesberiget læring kan derfor anses som værende gavnligt for alle børn.

Resultaterne af afhandlingen hjælper med at forstå virkningerne af bevægelser på børns læseevner. Det giver også evidens og forståelse for, hvilke bevægelsesformer der er gavnlige for at forbedre børns læseevner og staveevner. Den motoriske modalitet der tilknyttes den akademiske læring, er formegentlig ikke lige så vigtig som integrationen af bevægelse og læringsopgaven (opgaveintegration). Forhåbentlig kan afhandlingen bidrage til en øget opmærksomhed på vigtigheden af læringsaktiviteter med høj integration af bevægelse til læringselementet i folkeskoler.

Manuscripts Included in Thesis

- Manuscript I** **Motor-Enriched Encoding Can Improve Children’s Early Letter Recognition**
Linn Damsgaard, Sofie Rejkjær Elleby, Anne Kær Gejl, Anne Sofie Bøgh Malling, Anna Bugge, Jesper Lundbye-Jensen, Mads Poulsen, Glen Nielsen and Jacob Wienecke
Published: June 26, 2020, in Frontiers Educational Psychology
doi: 10.3389/fpsyg.2020.01207
- Manuscript II** **Effects of 8 Weeks with Embodied Learning on 5–6-Year-Old Danish Children’s Pre-reading Skills and Word Reading Skills: the PLAYMORE Project, DK**
Linn Damsgaard, Anne-Mette Veber Nielsen, Anne Kær Gejl, Anne Sofie Bøgh Malling, Søren Kildahl Jensen and Jacob Wienecke
Published: June 20, 2022, in Educational Psychology Review
- Manuscript III** **Embodied Learning Activities Focusing on Letter-Sound Knowledge Increase Spelling Performance in 1st grade Children with Low and High Reading Ability**
Linn Damsgaard, Anne-Mette Veber Nielsen, Marta Katarzyna Topor, Rasmus Ahmt Hansen, Søren Kildahl Jensen, Rebekka Læssøe Markers, Anne Kær Gejl, Anne Sofie Bøgh Malling, Jacob Wienecke
In review. Submitted: August 25, 2022, to Educational Psychology Review

Summary of thesis

Manuscript	Research Questions	Methods	Main findings
I	<ul style="list-style-type: none"> a) Can an acute setup of either fine-motor movement or gross-motor movement improve children's letter recognition? b) Can embodied learning activities improve children's motivation? 	<p>127 children from 1st grade were randomly assigned to receive 10 minutes training in the letter 'b' and 'd' with either non-motor movement (CON), fine-motor movements (FME) or gross-motor movement (GME). An 'b'/'d' recognition test before (T0), immediately after (T1), and one day after the intervention (T2) evaluated their letter recognition ability. Children's intrinsic motivation was measured at T1.</p>	<ul style="list-style-type: none"> a) Yes. Children in the FME group had a significantly higher accuracy compared to CON from T0-T1 and T0-T2. b) Both FME and GME revealed higher intrinsic motivation compared to CON, indicating that embodied learning is more intrinsically motivating.
II	<ul style="list-style-type: none"> a) Does embodied learning with different degree of motor modality affect children's letter-sound knowledge? b) Does embodiment with different degree of motor modality affect children's reading performance? c) Is there a correlation between children's baseline motor skills and their reading-related skills? 	<p>149 children from grade 0, were randomly assigned to either receive embodied learning activities with focus on letter-sound couplings using no-movements (CON), hand movements (HM) or whole-body movements (WM) for 8 weeks. Children got tested before (T1), after (T1) and 17-22 weeks after intervention in literacy skills.</p>	<ul style="list-style-type: none"> a) Yes. Overall, both HM and WM improved significantly compared to CON. b) We did not find a transfer effect from the intervention to children's reading performance c) We did not find any correlations between motor skills and reading-related skills
III	<ul style="list-style-type: none"> a) Can embodied learning improve children's reading and spelling performance? b) Is the effect of embodied learning determined by different levels in word reading performance (high/low performance)? 	<p>52 children from 1st grade were randomly assigned to either receive embodied learning activities with focus on literacy skills (MOVE) or continuing regular classroom teaching. Children got tested in literacy skills before (T1) and after (T2) a 4-week intervention period.</p>	<ul style="list-style-type: none"> a) Yes. Embodied learning activities improved children's spelling performance. No effect was seen for reading performance. b) No. Embodied learning is beneficial both for high performers and low performers based on their reading performance.